AERONAUTICAL AND ASTRONAUTICAL ENGINEER

DESIGN AND EVALUATION OF A DIGITAL FLIGHT CONTROL SYSTEM FOR THE FROG UNMANNED AERIAL VEHICLE

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The importance of unmanned aerial vehicles (UAVs) to current and future military operations cannot be understated. This rapidly developing field requires the ability to quickly develop and evaluate advanced control concepts. The FROG UAV serves as a test bed for advanced control and sensor projects at the Naval Postgraduate School. Previous control system projects have made use of a low performance electromechanical autopilot onboard the UAV. This autopilot imposed significant limitations on the responsiveness of the FROG. This project developed and tested an off board digital flight control system for use in lieu of the previous electromechanical device.

The digital flight controller was developed using the MatrixX rapid prototyping system and a previously validated dynamic model of the FROG. Surrogate flight control servo actuators were characterized in the laboratory and added to the plant model. Classic inner/outer loop controllers were developed for yaw damping and speed, altitude and heading control. The system was then successfully demonstrated with hardware in the loop in the lab.

The FROG was then instrumented and a command uplink latency of 170 ms was discovered. This introduced excessive phase lag into the system, which drove the flight controllers unstable. An alternate serial uplink method was developed and tested which reduced the command latency to 76 ms however the remaining phase lag resulted in limit cycle oscillation. Laboratory tests indicated that the current flight controller could withstand a maximum of 50 ms command path delay; without modification.

MECHANICAL ENGINEER

AN EXPERIMENTAL INVESTIGATION OF THE BOW WAVE ON *USS COLE* (DDG-67)
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This is an experimental investigation into the formation of the bow wave on *USS COLE* (DDG-67) and her 1/250 scale model. The experiment examines the bow wave from a hydrodynamic signature point of view. Previous experiments have looked at the phenomenon from an icing, deck wetness or hull resistance standpoint. Very little research has emphasized the importance to the Navy of the effects of the bow wave and subsequent spray on the overall radar cross-section and stealth of the vessel. Measurements were conducted on a 1/250-scale model and compared to video of the *USS COLE* (DDG-67) wherever possible. The effects of steady, heave, pitch and combinations of heave and pitch motions were studied to quantify the base flow in comparison to the *USS COLE*. The Froude Number for the majority of the work was 0.25. Model scale frequencies ranged from 1 to 5 Hz, pitch angles from 0.85 degrees to 3.75 degrees and heave amplitudes from 1/8 to 1/2 of an inch. This research, coupled with subsequent studies of sheet separation and a physics based understanding of all the mechanisms, is essential to developing a numerical model that could begin to predict the basics of the highly complex bow wave and spray region.

VALIDATION OF LOW OBSERVABLE STACK EDUCTOR DESIGN FOR GAS
TURBINE EXHAUST SYSTEMS
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An experimental and analytical program was conducted to improve the entrainment performance of a low aspect ratio mixing tube (about unity) eductor. A new primary flow pattern, consisting of eight high aspect ratio, pie-shaped nozzles, was designed to increase mixing and product better outlet flow uniformity. The aerodynamic performance of the new design was measured in a 1/5 scale, cold-flow facility, and the results compared to a nozzle plate with 16 constant-width, radial nozzles. Experimental results are presented for a range of conditions and include the effects of mixing tube misalignment and inlet blockage. The new nozzle is shown to increase the secondary pumping ratio by 7%. In addition, a one-dimensional, steady, analytical model of an educator, which includes frictional losses and outlet momentum non-uniformity is presented. The model predicts the performance of real eductors to within 3% and shows that the momentum non-uniformity is the primary factor limiting performance.

ELECTRICAL ENGINEER

PERFORMANCE ANALYSIS OF PILOT-AIDED FORWARD CDMA CELLULAR CHANNEL
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In this thesis the performance of the forward channel of a DS-CDMA cellular system operating in a Rayleigh-fading, Lognormal-shadowing environment is analyzed. An upper bound on the probability of bit error, including all the participating interference is developed. In addition, various techniques such as sectoring and forward error correction in the terms of convolutional encoding are applied to optimize the performance. The performance is further improved by applying a narrow bandpass filter in the pilot tone branch of the demodulator. The bandwidth of the filter is then adjusted in the means of the interference power passing through and observe the effects on the probability of bit error of the system. Moreover, pilot tone power control is added to enhance the demodulation. Finally, in this thesis a simple single cell system functioning as a port-to -port network communication between very small numbers of users is analyzed.

A 3D PARABOLIC EQUATION (PE) BASED TECHNIQUE FOR PREDICTING PROPAGATION PATH LOSS IN AN URBAN AREA
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A mobile radio environment places fundamental limitations on the performance of wireless communication systems. Most models developed to predict propagation path loss have been historically performed in a statistical approach. These models are expensive to develop and do not offer the accuracy, computational advantages, and sufficiency as the parabolic equation (PE). The goal of this thesis is to develop a 3D model based on PE for predicting propagation path loss in urban areas on flat and hilly terrains. The PE method offers the computational advantages, where one can approximate the elliptic operator governing the true wave behavior by a much simpler parabolic operator that permits marching in range. Moreover those all-important aspects of propagation such as reflection and diffraction are included automatically in the formulation. Four test problems on flat terrain and two test problems on hilly terrain will be simulated. For the flat terrain, the 3D PE model results will be compared with the two-ray, the four-ray, the UTD, and the numerical integration technique results. For the hilly terrain, the results of the 3D PE model will be compared with the UTD and the numerical integration technique results.

DESIGN AND IMPLEMENTATION OF A HIGH-POWER RESONANT DC-DC CONVERTER MODULE FOR A REDUCED-SCALE PROTOTYPE INTEGRATED POWER SYSTEM

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An Integrated Power System (IPS) with a DC Zonal Electrical Distribution System (DCZEDS) is a strong candidate for the next generation submarine and surface ship. To study the implementation of an IPS with DCZEDS, members of the Energy Sources Analysis Consortium (ESAC) are currently constructing a reduced-scale laboratory. One fundamental component of DCZEDS is the Ships Service Converter Module (SSCM), commonly known as a buck DC-DC converter. This thesis documents the design, simulation, construction and testing of a 500V/400V, 8kW resonant soft-switched DC-DC converter. In theory, resonant converters will operate more efficiently and generate less Electromagnetic Interference (EMI) when compared to a standard hard-switched converter. In this thesis, the resonant converter is tested and compared to a hard-switched DC-DC converter that was designed for ESAC's reduced-scaled IPS. The results verify that the resonant DC-DC converter realizes significant efficiency and EMI generation improvements over the hard-switched converter at the cost of a more complex control system and power section.